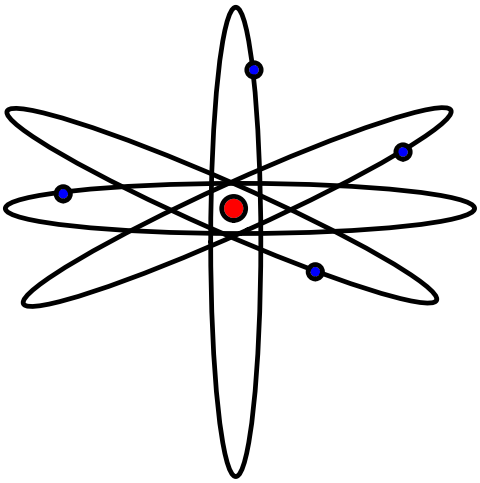
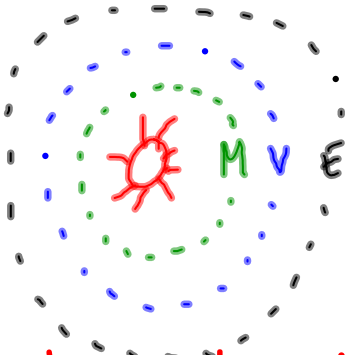
- Rutherford's model was disproved by Niels Bohr

- Was disproven because:
  - Rutherford's model did not explain why electrons did not collapse into the nucleus.

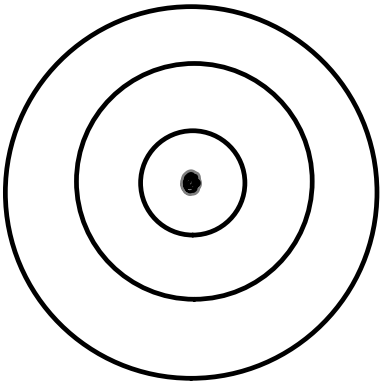
  - Did not explain how electrons are able to emit light



Neils Bohr

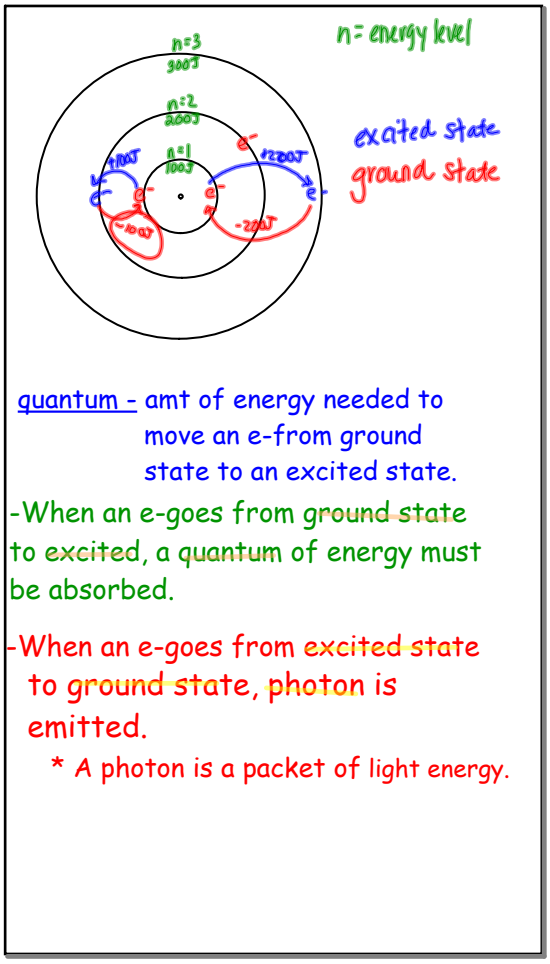


- e^- travel in paths around the nucleus like planets orbit the sun



- e^- travel around the nucleus in <u>orbits</u> or <u>energy levels.</u>

However, electrons are not confined to their paths. They can absorb or emit energy which affects where they are found around the nucleus.



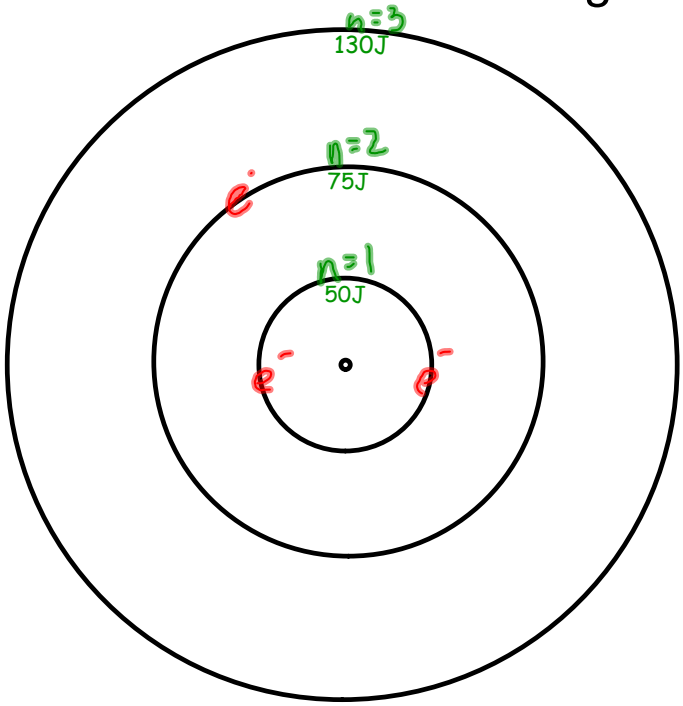
quantum - amt of energy needed to move an e- from ground state to an excited state.

-When an e- goes from ground state to excited, a quantum of energy must be absorbed.

-When an e- goes from excited state to ground state, photon is emitted.

* A photon is a packet of light energy.

Which electrons are in the ground state?

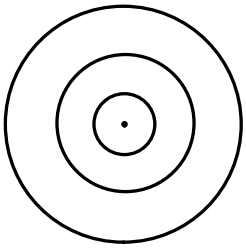


n = energy level

* There can be up to 7 energy levels.

Main Points of the Bohr Model

1. Electrons orbit the nucleus in orbits that have a set size and energy.
2. The energy of the orbit is related to its size. The lowest energy is found in the smallest orbit.
3. Light is absorbed or emitted when an electron moves from one orbit to another.



smaller orbit = smaller energy

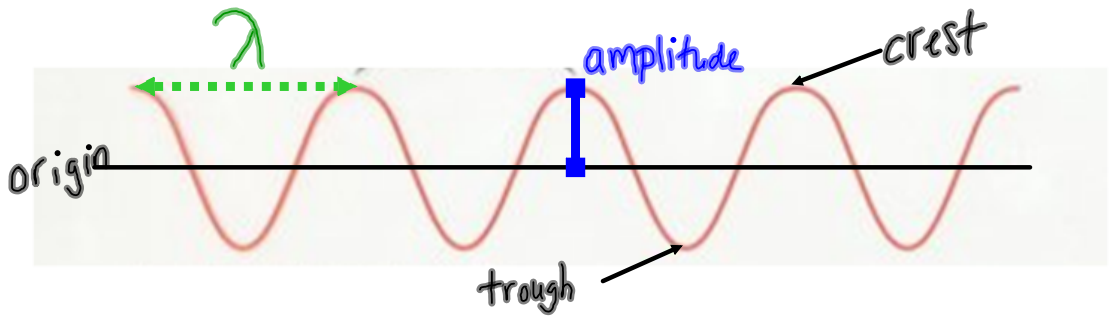
4. Explains why e^- do not collapse into the nucleus, because e- have a set amount of energy and cannot drop past the lowest energy level.

We know that electrons emit <u>photons</u> when they return to ground state. But how do photons travel?

Photons are particles (balls of light) that travel like a wave.

They DO NOT travel in a straight line!

What are the parts of a wave?



origin - where the wave begins and crosses as it moves up & down

crest - the top of a wave

trough - the bottom of a wave

amplitude - the distance from origin to crest

wavelength - the distance between adjacent crests of a wave λ

frequency - the number of wave cycles (completes an up/down motion) in a given time ν

Speed of light

Photons ***ALWAYS*** travel at the speed of light.

Speed of light (c) = 3.0×10^8 m/s

Speed of light = wavelength x frequency

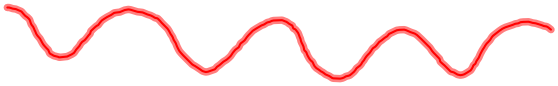
$c = \lambda \times \nu$

Frequency and wavelength are <u>inversely</u> proportional to each other.

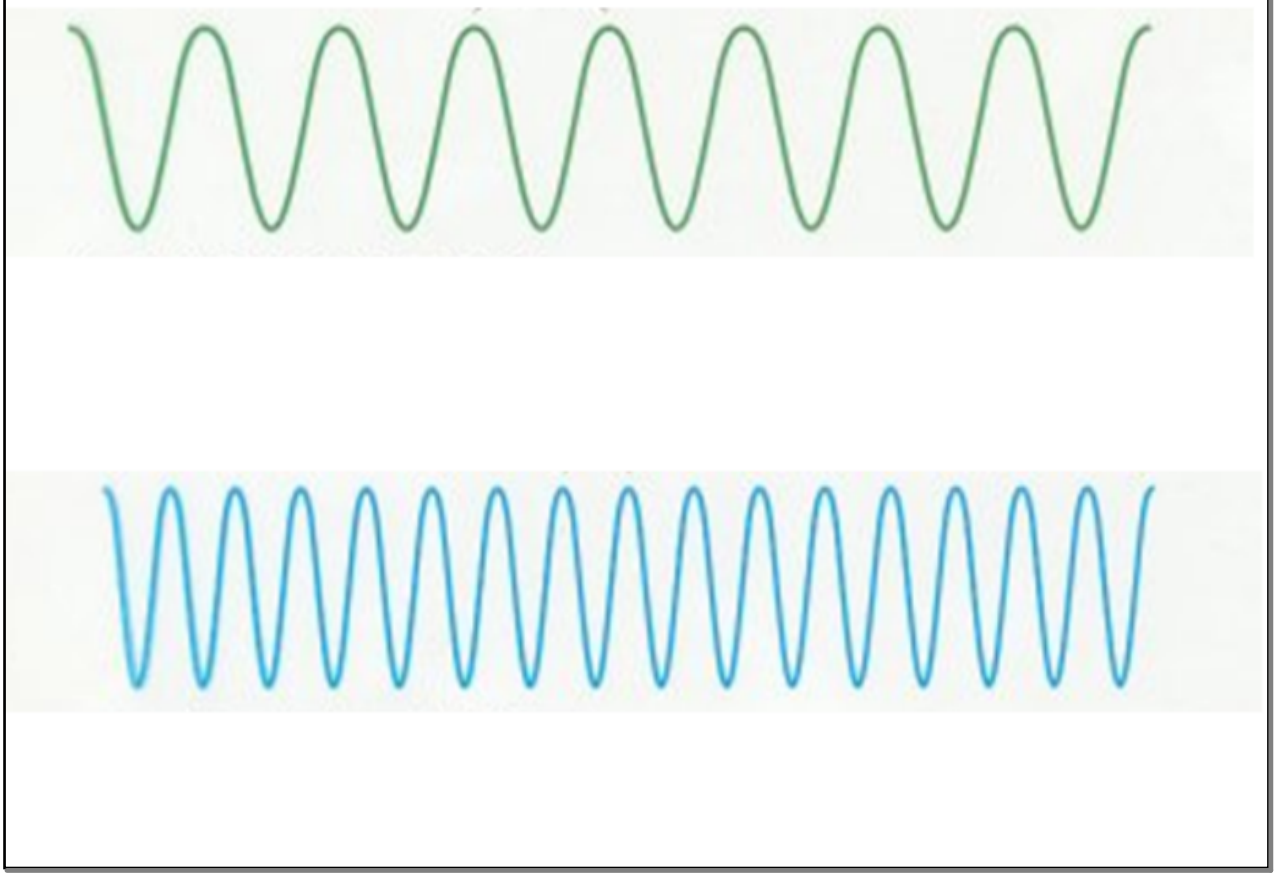
As frequency increases, wavelength decreases.

$\nu\uparrow$, $\lambda\downarrow$

As frequency decreases, wavelength increases



$\nu\downarrow$, $\lambda\uparrow$



Energy of a wave:

$$E = h\nu$$

Energy — frequency

Plank's constant = $6.626 \times 10^{-34}\ m^2kg/s$

(J)

Energy and frequency are **directly proportional!**

The Electromagnetic Spectrum

Shows all the types of radiation (light energy) that exists

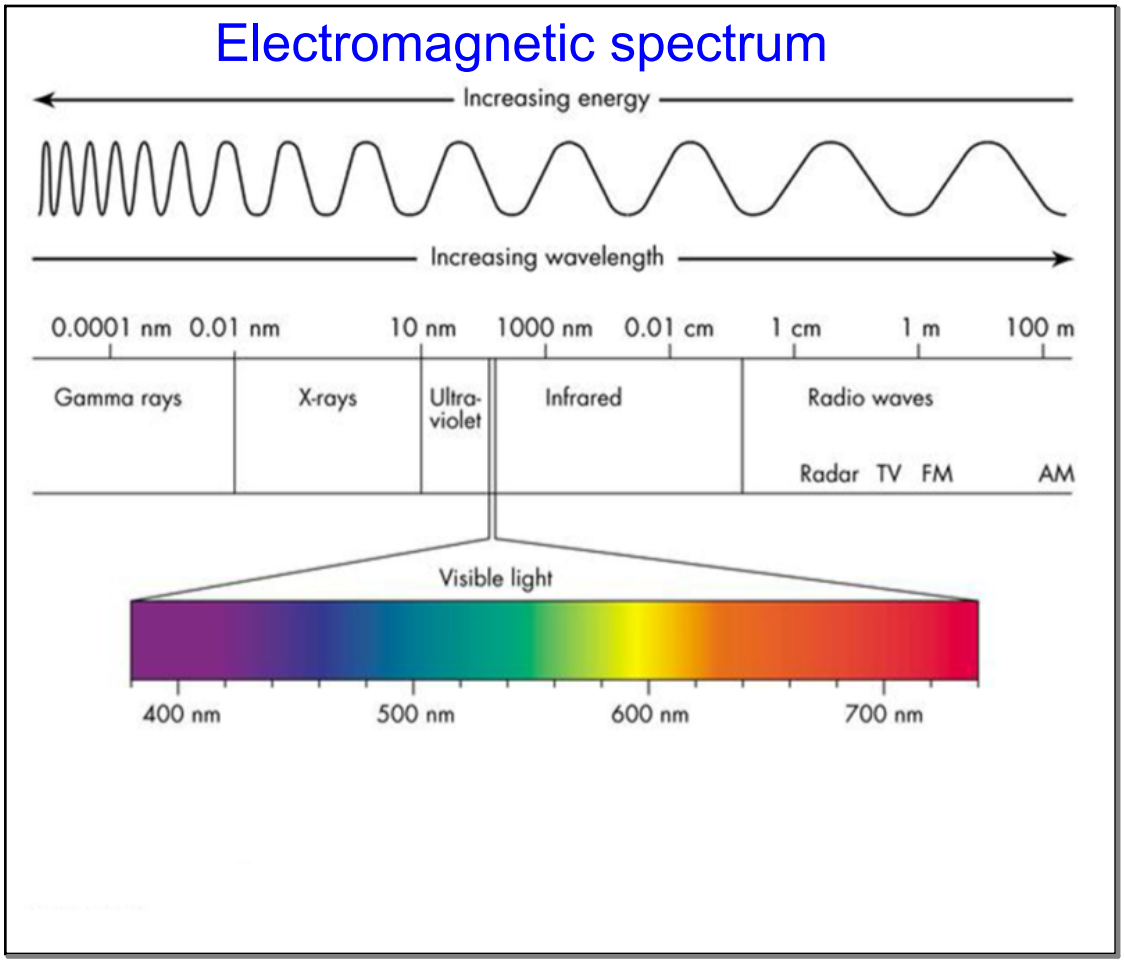
- Radiation is energy that travels and spread out as it goes.

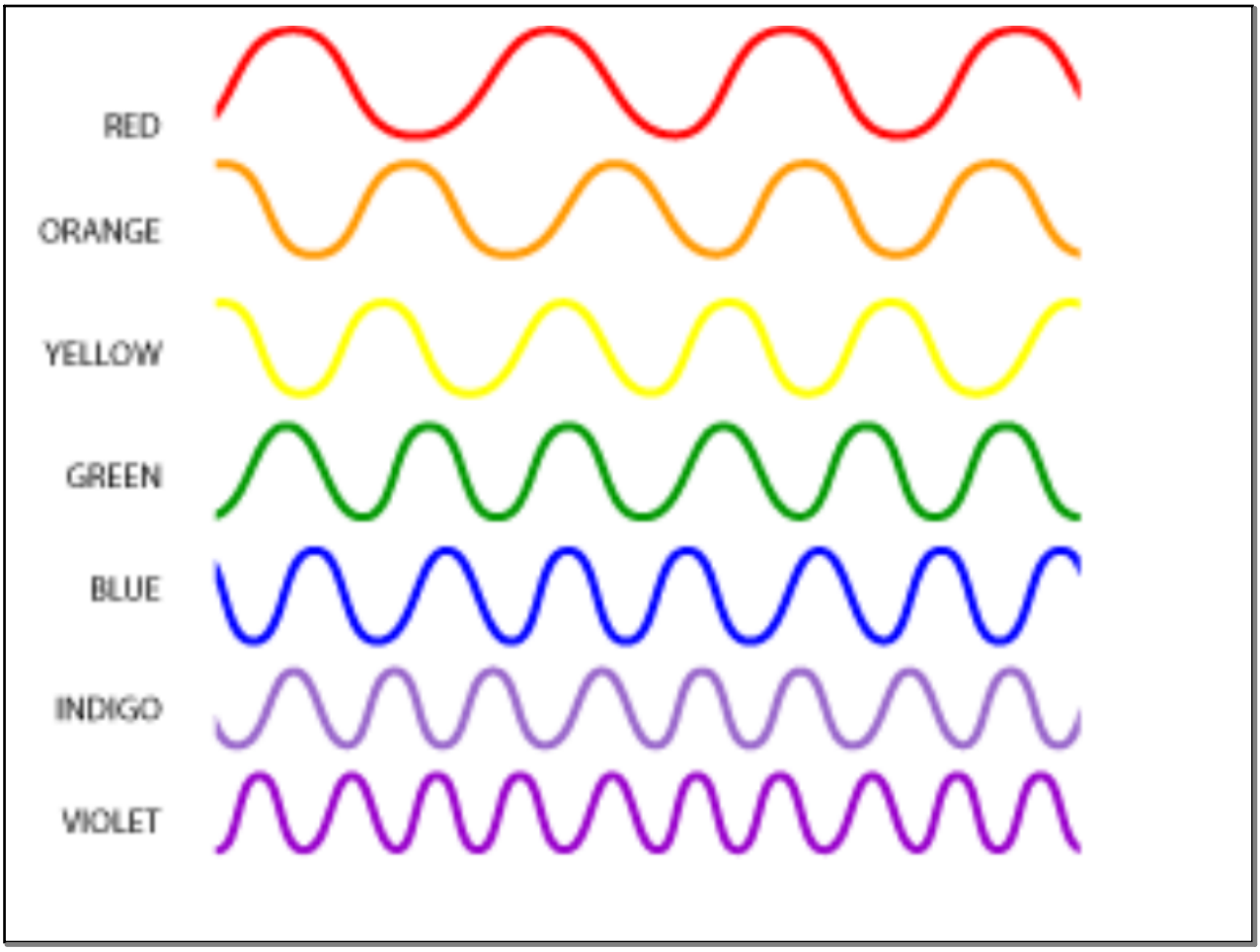
Radiation can be described as a stream of **photons.**

Each photon has a **certain amount of energy** in it (depending on how much quantum energy it absorbed).

The amount of energy absorbed determines the energy of the photon being released.

Using the energy of the photon, we can **determine which type of radiation** it will be.


Electromagnetic spectrum
Increasing energy
Increasing wavelength
0.0001 nm
0.01 nm
10 nm
1000 nm
0.01 cm
1 cm
1 m
100 m
Gamma rays
X-rays
Ultra-violet
Infrared
Radio waves
Radar
TV
FM
AM
Visible light
400 nm
500 nm
600 nm
700 nm

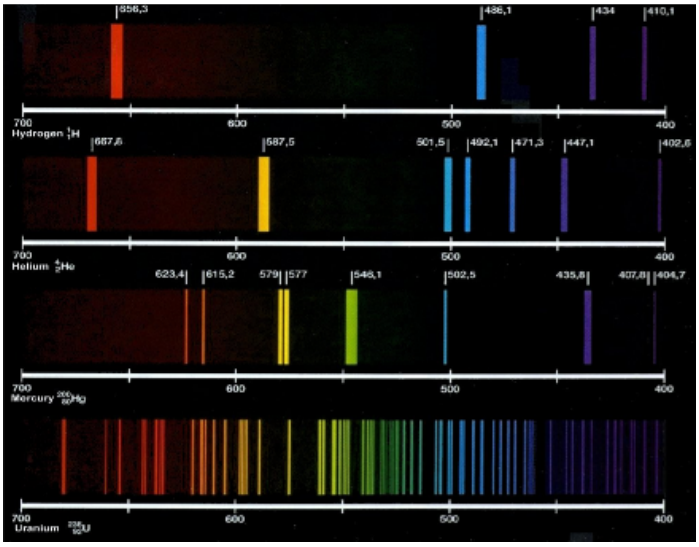

RED
ORANGE
YELLOW
GREEN
BLUE
INDIGO
VIOLET

Atomic Emission Spectra

These are the **fingerprints** of elements.

No two elements will have the same emission spectra.

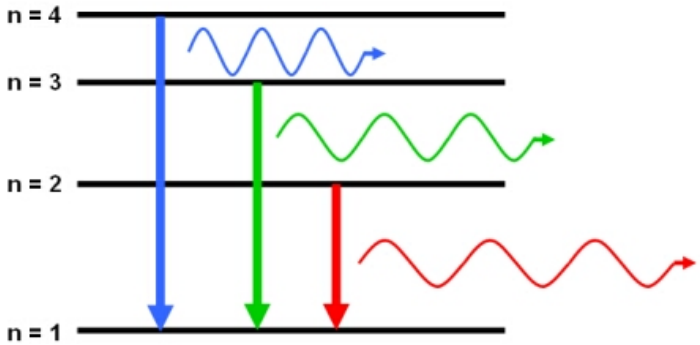
Can be used for determining new elements and looking at the composition of stars.

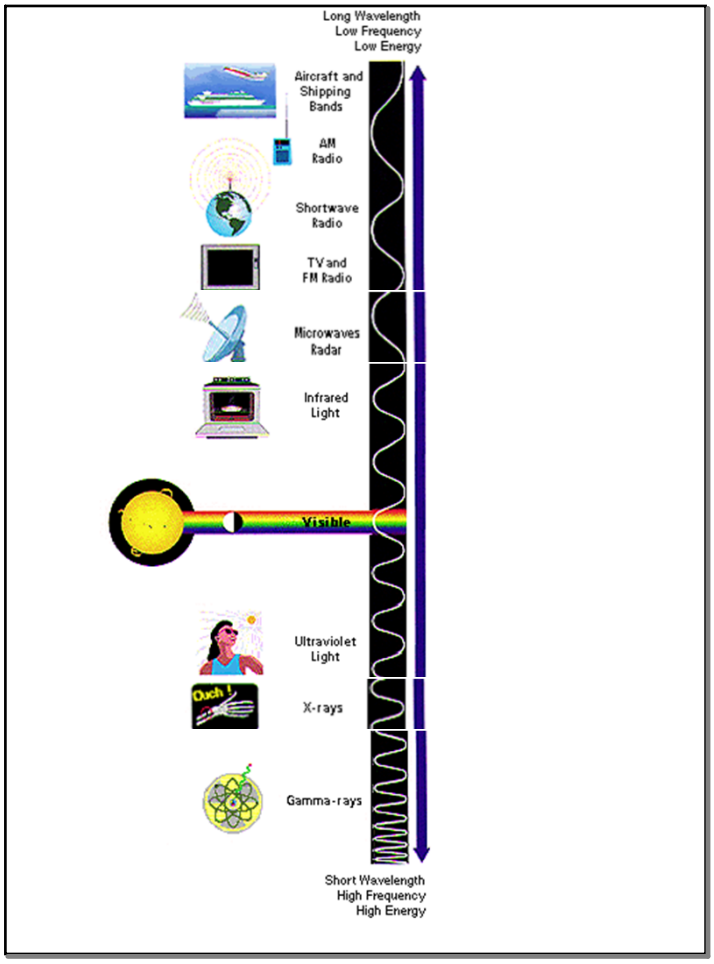


Why are there breaks in the spectra? Why aren't the colors continuous?

Some electrons in an atom may absorb more quantum energy than others.

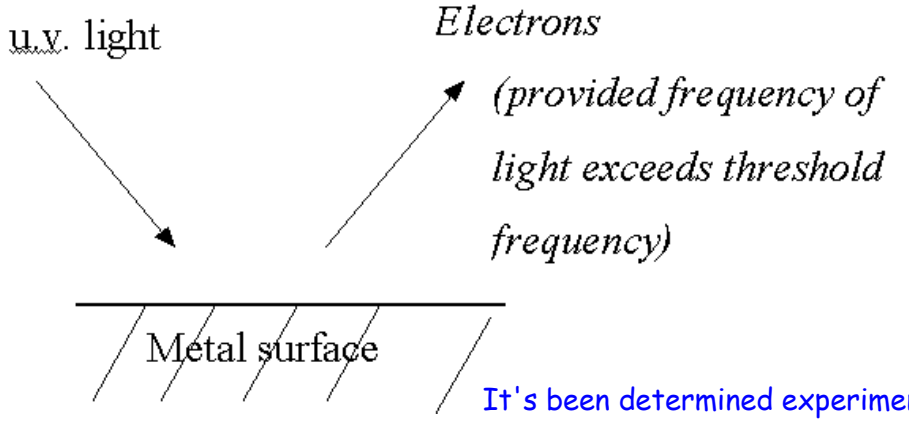
The emission lines in the spectra correspond to the **discrete (specific)** energies of the photons that are emitted.





Einstein's Photoelectric Effect

Showed light can sometimes act as a particle.



It's been determined experimentally that when light shines on a metal surface, the surface emits electrons. For example, you can start a current in a circuit just by shining a light on a metal plate.

We know that higher-frequency photons have more energy. They should make the electrons come flying out faster when shone onto a metal.

If you leave the frequency the same but increase the intensity, more electrons should come out (because there are more photons to hit them), but they won't come out any faster, because each individual photon still has the same energy.

Einstein actually won the Nobel Prize for his work on the photoelectric effect, not for his more famous theory of relativity.

Problems with the Bohr Model

It violates the Heisenberg Uncertainty Principle.

What is the Heisenberg Uncertainty Principle?

It is impossible to know the position and speed of an electron at the same time.

How do you find the position of an e^-?

To find position of e^-, shine light onto the atom.

The electron is absorb the light, revealing its position around the nucleus.

However, shining light also causes e^- to absorb energy = change in velocity.

How do you find the velocity of an e^-?

To find velocity, find the distance the electron traveled (ie: n=1 to n=3) and how long it took to make the jump.

However, by the time you figure out how fast the electron is traveling, it has already moved to a new position.

Therefore, current position is unknown.